



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/US88/02622</p> <p>(22) International Filing Date: 1 August 1988 (01.08.88)</p> <p>(31) Priority Application Number: 091,227</p> <p>(32) Priority Date: 31 August 1987 (31.08.87)</p> <p>(33) Priority Country: US</p> <p>(71) Applicant: SANTA BARBARA RESEARCH CENTER [US/US]; 75 Coromar Drive, Goleta, CA 93117 (US).</p> <p>(72) Inventor: DOTY, Fred, Patrick ; Rt. 1 Box 254, Earlys-ville, VA 22936 (US).</p> <p>(74) Agents: SCHUBERT, William, C. et al.; Hughes Aircraft Company, Post Office Box 45066, Bldg. C1, M/S A-126, Los Angeles, CA 90045-0066 (US).</p>		<p>(81) Designated States: DE (European patent), FR (European patent), GB (European patent), IT (European patent), JP, NL (European patent).</p> <p>Published <i>With international search report.</i></p>
<p>(54) Title: IN-SITU GENERATION OF VOLATILE COMPOUNDS FOR CHEMICAL VAPOR DEPOSITION</p> <p>(57) Abstract</p> <p>Method and apparatus for the in-situ generation of volatile compounds within the process piping of a CVD system. A source of molecules is located upstream from a solid material which is desired to be deposited within a reactor chamber of the system. The molecules are acted upon by a disassociation means, such as a pyrolytic, plasma discharge, or radiation means, to form highly reactive free radicals. These free radicals are fragments of molecules containing unpaired electrons. In accordance with the invention, these highly reactive radicals are generated near the solid source material in a gas stream which transports the radicals to the solid material before the radicals recombine with one another to form unreactive molecules. The free radicals react with the solid source material to form volatile compounds, such as organometallic compounds, which are subsequently conveyed to the reaction chamber of the system for deposition therein.</p>		

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1        IN-SITU GENERATION OF VOLATILE COMPOUNDS FOR  
         CHEMICAL VAPOR DEPOSITION

FIELD OF THE INVENTION

5

The present invention relates to chemical vapor deposition (CVD) and, in particular, to the in-situ generation of volatile compounds for use in a CVD reactor.

10

BACKGROUND OF THE INVENTION

CVD reactors of the prior art, such as metalorganic chemical vapor deposition (MOCVD) reactors, have  
15 typically used reservoirs of previously prepared organometallic compounds as sources for reactants. As is well known, these compounds may be extremely toxic and pyrophoric and, in general, are difficult to handle and store. The volatility, reactivity, and the  
20 tendency of these compounds to readily decompose when exposed to air and moisture has presented a formidable problem. In addition, a complex array of process piping and valves is typically required to deliver the needed quantities of reactants to the MOCVD reactor.  
25 Also, separate temperature controls are generally required for each such source of reactants.

MOCVD systems are used, typically, for the deposition of type III-IV and II-VI semiconductors, as well as

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1 ceramics, metals and metal alloys. The volatile  
organometallic source compounds in these MOCVD systems  
are typically prepared as a gas or a high vapor  
pressure liquid which is stored in a reservoir. A  
5 carrier gas such as hydrogen is "bubbled" through the  
reservoir and the source compound and the carrier gas  
are subsequently introduced by means of metered valves  
into the reactor, or deposition, chamber. Within the  
chamber the volatile compound or compounds are  
10 decomposed and the desired material is deposited  
therein. The delivery of a known or reproducible  
amount of reactant to the deposition chamber requires  
independent temperature and carrier gas flow control  
mechanisms for each type of required reactant.

15 As can be appreciated from the foregoing, the required  
storage of relatively large quantities of these highly  
toxic and unstable organometallic source compounds has  
presented a serious problem. In addition, the  
20 implementation of the complex piping and process  
control mechanisms required to introduce desired  
amounts of these organometallics into the MOCVD reactor  
has also presented a serious problem.

25 One further disadvantage of these systems of the prior  
art is that the use of liquid reservoirs of source  
compounds in conjunction with a carrier gas "bubbler"  
is inappropriate in a zero gravity environment such as  
is found in a spacecraft. Thus, the use of such prior  
30 art CVD systems to produce, for example, high-quality  
semiconductor devices in an orbiting production  
facility is foreclosed by the reliance of such systems

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1 of the prior art on gravitational force for proper operation.

### SUMMARY OF THE INVENTION

5 The foregoing problems are overcome and other advantages are realized by a CVD system which, in accordance with the apparatus and method of the invention, allows for the in-situ generation of  
10 volatile compounds, such as organometallic compounds, within the process piping of the CVD system. In accordance with the invention, a source of molecules is located upstream from a source of solid material which is to be deposited in the reactor chamber, the solid  
15 material being in communication with an interior portion of the process piping. The molecules, for example organic molecules, are acted upon by a disassociation means, such as a pyrolytic, plasma discharge, or radiation means, to form highly reactive  
20 free radicals. These free radicals are fragments of the organic molecules and contain unpaired electrons. These highly reactive radicals are generated near the solid material in a gas stream which transports the radicals to the solid material before the radicals  
25 recombine with one another to form unreactive molecules. The free radicals react with the atoms of the solid material to form, for example, organometallic compounds which are subsequently conveyed to the reactor chamber of the system wherein  
30 the atoms are deposited.

In one embodiment of the invention a pyrolysis reaction

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1 is utilized to form free radicals within a portion of  
the CVD process piping. The pyrolysis reaction is  
accomplished by a resistive heating element which  
surrounds the portion of the process piping, the  
5 heating element creating a high temperature region  
which acts to form free radicals from the organic  
source molecules. In other embodiments of the  
invention the free radicals are created by an  
electrical discharge which produces a plasma region  
10 within the process piping, or by an ultraviolet light  
source, the radiation from the light source creating  
the free radicals.

After being so generated, the free radicals are carried  
15 downstream by a carrier gas flow and pass over the  
surface of the solid source material, the material  
containing a material which is desired to be deposited  
within the reactor chamber. The free radicals react  
with the surface of the material such that atoms of the  
20 material bind to the free radicals and are subsequently  
conveyed into the reactor chamber where the atoms may  
be deposited as films or thin layers, as is typically  
done within a CVD reactor chamber. Bulk crystal growth  
and whisker growth may also be achieved in this manner.

25  
In accordance with the invention, a single stream of  
free radicals within a portion of a primary process  
tube may be subsequently divided by branches provided  
from the primary process tube such that each subdivided  
30 stream may come in contact with a different desired  
solid compound or element, thus, a great simplification  
is achieved in the generation of such organometallics.

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- 1 Alternatively a single solid source material comprised  
of, for example, an alloy containing a plurality of  
desired source materials may be utilized within the  
primary process tube. Thus, a plurality of volatile  
5 compounds may be simultaneously generated by a single  
stream of free radicals.

The use of the apparatus and method of the invention  
obviates the need for the storage of these toxic and  
10 highly reactive organometallics, instead, the  
organometallics are generated as required within the  
process piping of the CVD system itself.

#### BRIEF DESCRIPTION OF THE DRAWINGS

15

Fig. 1 illustrates a portion of a process tube which  
allows for the pyrolytic generation of free radicals;

20

Fig. 2 illustrates a portion of a process tube which  
allows for the generation of free radicals by plasma  
discharge;

25

Fig. 3 illustrates a portion of a process tube which  
allows for the generation of free radicals by a source  
of ionizing radiation; and

Fig. 4 illustrates a portion of a process tube which  
allows for the generation of one or more desired  
volatile compounds from a single solid source material.

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## 1 DETAILED DESCRIPTION OF THE INVENTION

Referring now to Fig. 1, there is shown a portion of the process piping for a chemical vapor deposition (CVD) reactor system. A primary portion of a process tube 10 has a plurality of branches, or secondary portions, projecting therefrom, shown in Fig. 1 as tubes 12, 14 and 16. Although three such branches are shown in the Figures, it is understood that more or less than three may be employed, depending upon the requirements for a particular application. The use of three such branches advantageously provides for three separate streams of highly reactive free radicals to be provided to three separate solid sources, shown generally as 18, 20 and 22. Tube 10 and the branches thereof are comprised of a suitable refractory material such as quartz. Surrounding a portion of tube 10 is a pyrolytic disassociation means such as a resistive heating element 24 having a plurality of resistive heater windings 26 contained therein. Element 24 is electrically connected to a source of heater power (not shown) in order that the portion of tube 10 contained within element 24 may be raised to an elevated temperature. The arrow A indicates the direction of flow of a gas stream containing molecules to be dissociated into free radicals, the source of the molecules being provided by a suitable means at an upstream portion (not shown). The molecules may be organic molecules or inorganic molecules such as hydrogen. As the gas stream A passes through the portion of tube 10 within element 24, a pyrolytic reaction occurs due to the elevated temperature of this

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1 portion of the tube 10. As a result, the molecules  
within the stream A are disassociated into a stream of  
free radicals, shown as the arrow A'. This stream of  
free radicals A' is divided within the branches 12, 14  
5 and 16 of tube 10 such that each of the solid materials  
18, 20 and 22 has a portion of a free radical stream A'  
passing over at least one surface thereof. Each such  
source of solid material may be comprised of a metal,  
for example antimony or cadmium, a non-metal, such as  
10 silicon or tellurium, or an alloy. The solid material  
may also be in the form of an elemental source of the  
desired material, or may comprise compounds of the  
desired material, or a compound comprised of two or  
more desired materials. In addition, a liquid material  
15 such as mercury may be employed.

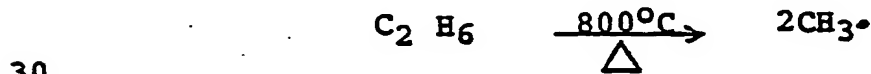
In accordance with the invention, the stream of free  
radicals interacts with the surface of the solid  
material such that an atom of the solid material is  
20 bonded to, typically, more than one of the free  
radicals passing thereover. The resulting stream of  
gas in each of the branches, shown as the arrows B, C  
and D, therefore contains, for example, organometallic  
molecules which are carried to a downstream region of  
25 the CVD reactor system (not shown) where vapor  
deposition occurs. A carrier gas stream may also be  
included as part of the gas stream A within the tube 10  
for transporting the free radicals and the volatile  
product molecules to the downstream portion. A  
30 plurality of metering valves 28a, 28b and 28c may also  
be included for selectively allowing or inhibiting the  
flow of gas streams B, C and D, respectively.

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1 The branches of the process tube make it possible to  
have a single radical source provide free radicals to a  
plurality of separate solid sources. In this manner  
ternary materials such as CdZnTe and CdMnTe can be  
5 deposited using elemental metallic sources. It is also  
possible to use compounds such as HgTe or HgZnTe to  
deposit binary or ternary materials.

For example, it has been found that the half-life of  
10 methyl radicals ( $\text{CH}_3\cdot$ ) is approximately  $10^{-2}$  seconds.  
This half-life is adequate for the radicals to form  
volatile antimony compounds with a source of solid  
antimony which is located approximately 37 centimeters  
15 downstream from the portion of the process tube where  
the free radicals are generated. The formation of  
these antimony compounds is found to occur at an  
appreciable rate. In general, if alkyl radicals are  
generated near a solid element or compound, they will  
20 readily react with the element or compound to form  
volatile, easily pyrolysed compounds which have a  
carbon atom bonded directly to a atom of the solid or  
compound.

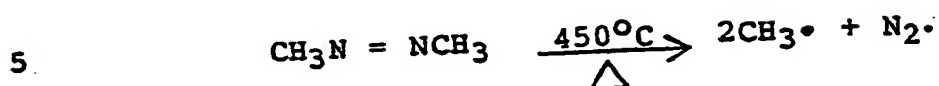
Of the many possible pyrolysis reactions which may form  
25 free radicals, two examples are now given. Ethane, a  
typical paraffin, decomposes above  $800^\circ\text{C}$  to yield  
methyl



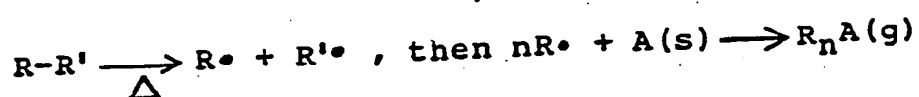
which reacts directly with solid metallic source  
materials to yield methylated compounds.

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- 1 Another possible pyrolysis reaction, which is attractive due to the relatively low temperature required, is that of azomethane



In general, such reactions take the form:



where R, R' can be H, alkyl groups, oxygen bearing groups forming peroxides or ethers, etc.

- Referring now to Fig. 2 there is shown another embodiment of the present invention. As in Fig. 1, a portion of a process tube 30 has a plurality of branches 32, 34 and 36. A stream of organic molecules A enters a region of the tube 30 from an upstream source (not shown) of organic molecules. A pair of electrodes 38 and 40 are connected to a source of discharge voltage 42, the magnitude of the voltage being sufficient to create a plasma region within the tube 30 between the two electrodes 38 and 40. The stream A as it passes through the plasma created between electrodes 38 and 40 is disassociated into a stream of organic radicals A' which are subsequently conveyed to a plurality of solid sources such as is depicted in Fig. 1.

- 30 Fig. 3 shows yet another embodiment of the present invention wherein a process tube 50 having a plurality

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of branches 52, 54 and 56 is provided with a source of ionizing radiation, the radiation in Fig. 3 being depicted as ultraviolet (UV) radiation. An UV source 58 may be positioned adjacent to the tube 50 in order that the UV radiation, shown as the arrows 60, may enter the tube 50. Of course, in the embodiment of the invention shown in Fig. 3 the tube 50 must be comprised of a material suitable for admitting the radiation 60 therein. Alternatively, the source 58 may be incorporated within the tube 50. As has been previously described, a flow of organic molecules A passes through this region of tube 50 where the UV radiation 60 causes the molecules to be disassociated into free organic radicals, shown as the arrow A'. The free radicals are subsequently conveyed to separate sources of solid material (not shown) by the branches 52, 54 and 56.

In the embodiment of Fig. 3, the organic molecules A may be comprised of  $(\text{CH}_3)_3\text{CO-OC}(\text{CH}_3)_3$  which, under the influence of the UV radiation 60, is disassociated into  $2 \text{ C}_4\text{H}_9\text{O}\cdot$ .

In general, if the disassociation means chosen for a given application acts by pyrolysis or by plasma discharge, substantially all known organic molecules may be disassociated thereby into a stream of free radicals. If, however, a source of ionizing radiation is employed, such as UV radiation, selected organic molecules may need to be employed, the molecules being selected for their susceptibility to breakdown induced by the radiation.

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1 Thus, it may be seen that the use of the apparatus and  
method of the present invention allows for the in-situ  
generation of highly reactive free organic radicals  
within the process piping of a CVD reactor. Such in-  
5 situ generation of these radicals eliminates the  
requirement for storing relatively large quantities of  
organometallics within or near the reactor system. In  
accordance with the invention, after being generated  
the free radicals interact with the solid source  
10 material in order to generate a supply of  
organometallics for deposition within the reactor.  
The elimination of reservoirs of liquid organometallics  
further results in the elimination of the typically  
complex temperature and metering controls which are  
15 required to introduce known or reproducible quantities  
of organometallics into the reactor. Instead,  
relatively simple flow controllers may be employed  
downstream from the site where the organometallics are  
generated within the piping, the flow controllers  
20 permitting desired amounts of organometallics to pass  
through. The elimination of these reservoirs of  
volatile compounds also provides for a CVD system which  
is particularly well adapted for use in a zero gravity  
environment.

25 As has been previously mentioned, the method and  
apparatus of the invention may be utilized with a wide  
variety of solid source materials, both metallic and  
non-metallic, and with a variety of free radicals  
30 species such as, for example, atomic hydrogen.

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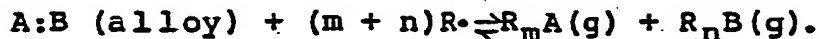
- 1 One particular volatile compound that is especially  
desireable to generate is hydrogen telluride which, due  
to its instability, is difficult to store in the  
reservoir-type CVD systems of the prior art. The use  
5 of the invention allows for the in-situ generation of  
hydrogen telluride in an "on demand" basis, thereby  
eliminating such a storage requirement.

10 In general, a desired tellurium compound in solid form  
is reacted with free radicals of atomic hydrogen in  
accordance with the formula



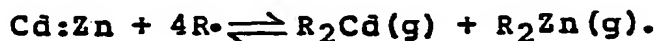
- 15 The hydrogen telluride is subsequently decomposed  
within the CVD reactor by conventional means in order  
to deposit the desired tellurium compound.

20 Also, solid compounds or mixtures comprised of two or  
more materials which are desired to be deposited may be  
employed as the solid source material in accordance  
with the general formula:



25

A specific example of this formula is:



- 30 This feature of the invention is advantageous in that  
it provides for the in-situ generation of two or more  
volatiles within one portion of the process piping,

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1 thus reducing the required amount and complexity of the  
piping and the associated components, such as flow  
controllers. As illustrated in Fig. 4, a portion of a  
process pipe 62 has a disassociation means 64 coupled  
5 thereto, the disassociation means 62 comprising, for  
example, the pyrolytic disassociation means of Fig. 1.  
A flow of molecules A is disassociated by means 64 to  
form a flow of free radicals B. These radicals B react  
with a solid source material 66 comprised of, in  
10 accordance with the foregoing example, a CdZn alloy.  
The resultant flow of volatile compounds comprises  
cadmium volatiles C and zinc volatiles D which are  
transported to the CVD reactor (not shown) wherein the  
volatiles C and D are decomposed by conventional  
15 techniques in order to deposit the desired Cd and Zn.

It should be appreciated that the use of the present  
invention also provides for the in-situ generation of  
volatiles which are not commercially available due to,  
20 for example, their inherent instability.

While the present invention has been described in the  
context of preferred embodiments thereof, it will be  
readily apparent to those skilled in the art that  
25 modifications and variation can be made therein without  
departing from the spirit and scope of the present  
invention. For example, one such modification may be  
the replacement of the resistive heating element of  
Fig. 1 with another pyrolytic disassociation means such  
30 as a flame directed against the outer walls of the  
process tube. Accordingly, it is not intended that the  
present invention be limited to or by the specifics of

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- 1 the foregoing description of the preferred embodiments, but rather only by the scope of the invention as defined in the claims appended hereto.

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## CLAIMS

What is claimed is:

- 1 1. A method of generating a volatile compound for use in a CVD system, comprising the steps of:
  - 5 providing a source of molecules;
  - introducing the molecules into a predetermined region of a process pipe coupled to the system;
  - 10 disassociating the molecules within the predetermined region to generate free radicals therefrom;
  - 15 passing the radicals over a solid source of material, the material being a material desired to be deposited within the system, the radicals reacting with the material to generate a volatile compound; and
  - 20 directing the volatile compound into a portion of the system wherein the volatile compound is decomposed and the material is deposited.
  - 25
- 1 2. The method of Claim 1 wherein the step of disassociating is accomplished by heating the

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predetermined region to a temperature sufficient to disassociate the molecules into free radicals.

1           3. The method of Claim 1 wherein the step of disassociating is accomplished by generating an electrical plasma within the predetermined region.

1           4. The method of Claim 1 wherein the step of disassociating is accomplished by irradiating the predetermined region with a source of ionizing radiation, the radiation having sufficient energy to  
5 disassociate the molecules into free radicals.

1           5. The method of Claim 4 wherein the radiation is generated by an ultraviolet radiation source.

1           6. The method of Claim 1 wherein the step of introducing further comprises a step of providing a carrier gas flow for carrying the molecules into the predetermined region.

1           7. The method of Claim 1 wherein the step of passing is accomplished at a time before the free radicals have substantially recombined into unreactive molecules.

1           8. A method of generating a plurality of volatile compounds within CVD system, comprising the steps of:

5           generating a primary supply of free

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radicals within a portion of a process pipe of the system;

dividing the supply into a plurality of secondary supplies of free radicals;

10

passing each one of the secondary supplies over a respective material which is desired to be deposited within the system, each of the secondary supplies reacting with the associated material to generate a volatile compound; and

15

20

selectively directing each of the volatile compounds so generated into the system for deposition of the material.

1

9. The method of Claim 8 wherein the step of dividing is accomplished by providing the process pipe with a plurality of branches projecting therefrom.

1

10. The method of Claim 9 wherein the step of passing further comprises a step of providing within each one of the branches one of the materials desired to be deposited within the system.

1

11. The method of Claim 10 wherein the step of selectively directing is accomplished by providing each of the branches with a valve means operable for passing a desired amount of a volatile compound therethrough.

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1           12. Apparatus for the in-situ generation of  
volatile compounds within the process piping of an  
MOCVD system comprising:

5           means for providing a source of  
molecules to a portion of the process  
piping;

10           means for disassociating said molecules  
into free radicals, said disassociating  
means being operable for disassociating  
said molecules within said portion of  
said process piping; and

15           means for contacting said radicals with  
at least one source of solid material  
such that said radicals react with and  
bond to said material whereby one or  
more volatile compounds containing atoms  
20           from said material are generated within  
said process piping.

1           13. The apparatus of Claim 12 wherein said  
disassociating means is a heating element thermally  
coupled to said portion of said process piping.

1           14. The apparatus of Claim 12 wherein said  
disassociating means is a first and a second electrode  
disposed within said process piping, said electrodes  
being electrically coupled to a voltage source operable  
5           for generating a plasma region between said electrodes

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and within said portion of said process piping.

1           15. The apparatus of Claim 12 wherein said  
disassociation means is a source of ionizing radiation  
radiatively coupled to said portion of said process  
piping.

1           16. The apparatus of Claim 12 wherein said  
portion of said process piping has a plurality of  
branches projecting therefrom, each of said branches  
5           having an interior region communicating with a solid  
source of atoms and conveying a portion of said free  
radicals therethrough such that a plurality of volatile  
compounds are substantially simultaneously generated  
within each of said branches.

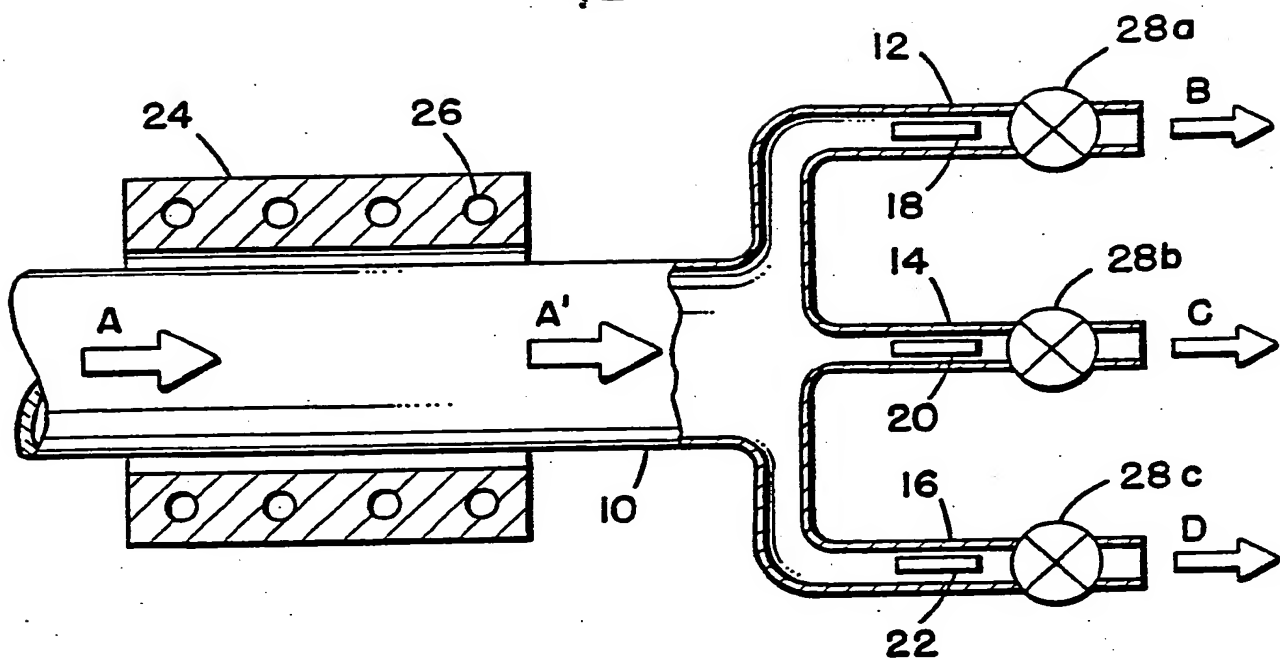
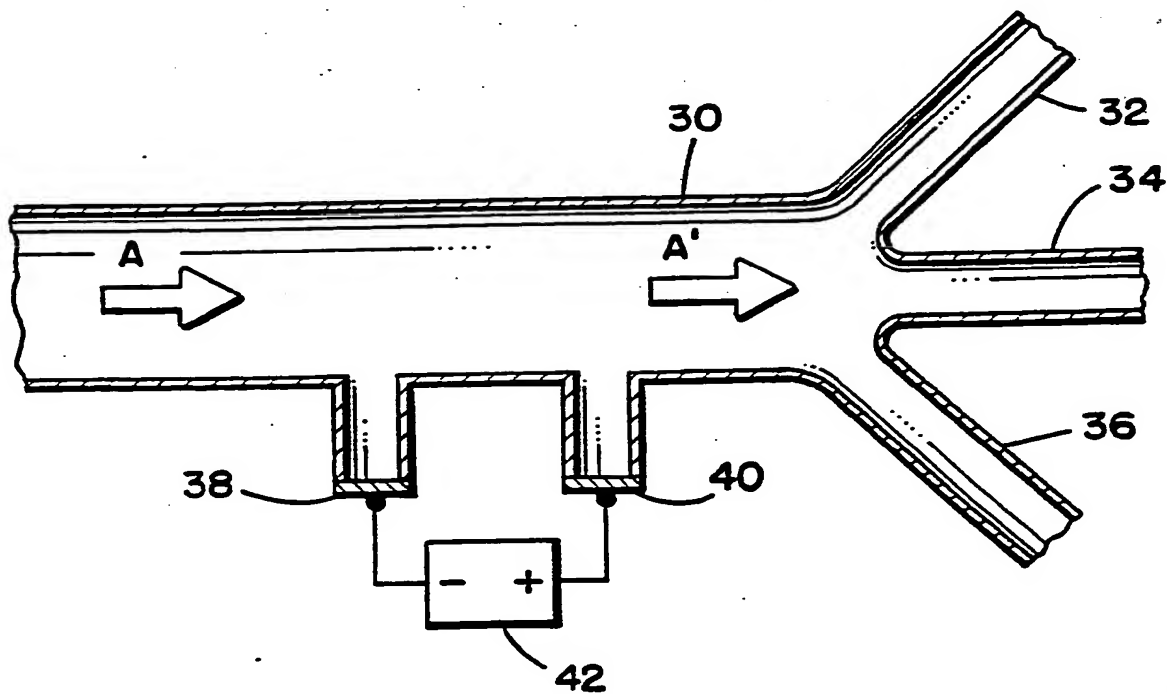
1           17. The apparatus of Claim 16 further  
comprising a plurality of valve means, each one of  
which is coupled to a respective one of said branches  
5           for selectively passing an associated volatile compound  
therethrough.

1           18. The apparatus of Claim 12 wherein said  
molecules are organic molecules.

1           19. The apparatus of Claim 12 wherein said  
free radicals are atomic hydrogen and wherein said  
source of solid material is comprised of a tellurium  
compound.

1           20. The apparatus of Claim 12 wherein said  
source of solid material is an alloy.

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FIG. 1.FIG. 2.

2/2

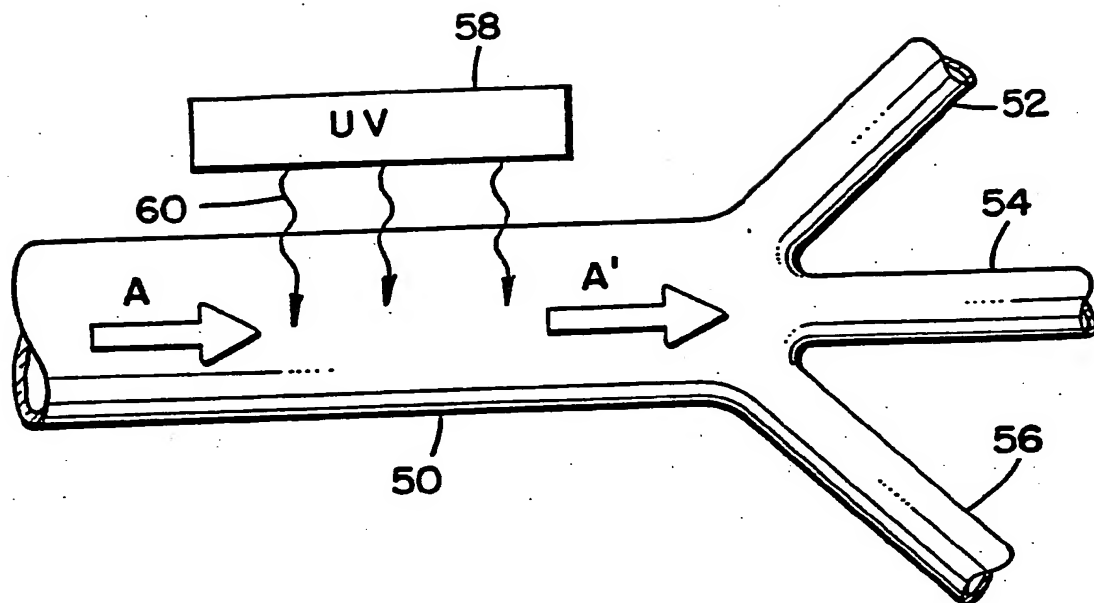


FIG. 3.

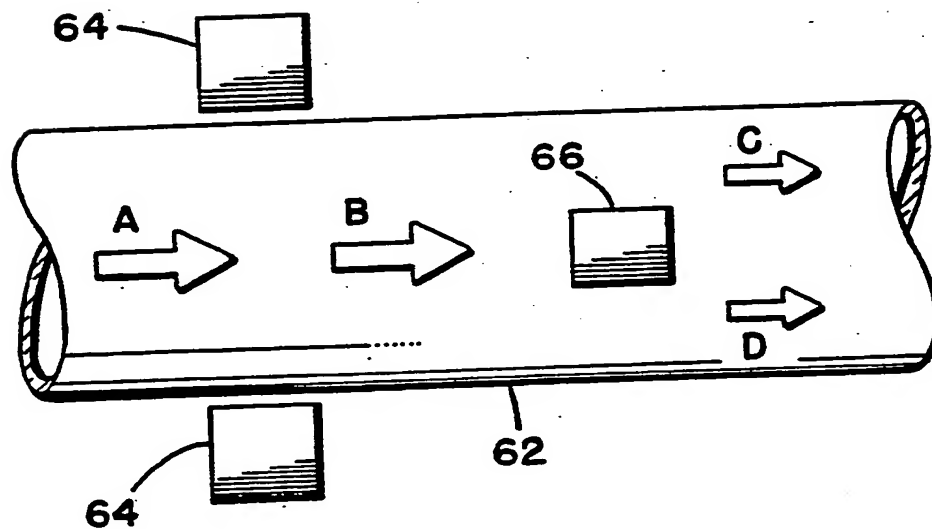


FIG. 4.

# INTERNATIONAL SEARCH REPORT

International Application No PCT/US 88/02622

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) * According to International Patent Classification (IPC) or to both National Classification and IPC IPC <sup>4</sup> : C 23 C 16/44																							
<b>II. FIELDS SEARCHED</b> <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black;">Minimum Documentation Searched <sup>7</sup></div> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 25%; border-bottom: 1px solid black;">Classification System</td> <td style="border-bottom: 1px solid black;">Classification Symbols</td> </tr> <tr> <td style="padding: 5px;">IPC<sup>4</sup></td> <td style="padding: 5px;">C 23 C; C 30 B</td> </tr> </table> <div style="border-top: 1px solid black; padding-top: 5px;">           Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup> </div>			Classification System	Classification Symbols	IPC <sup>4</sup>	C 23 C; C 30 B																	
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IPC <sup>4</sup>	C 23 C; C 30 B																						
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b> <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 10%; border-bottom: 1px solid black;">Category *</th> <th style="width: 70%; border-bottom: 1px solid black;">Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup></th> <th style="width: 20%; border-bottom: 1px solid black;">Relevant to Claim No. <sup>13</sup></th> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">X</td> <td style="padding: 5px;">EP, A, 0140625 (THE MARCONI CO. LTD) 8 May 1985, see abstract; page 4, lines 5,6; page 5, lines 3-12; page 5, lines 19-23; page 6, lines 13-20; figure 1</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1,3,4,6, 12,14,15,19</td> </tr> <tr> <td colspan="3" style="text-align: center; padding: 5px;">--</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">A</td> <td style="padding: 5px;">WO, A, 85/03460 (SCHMITT JEROME) 15 August 1985, see abstract; page 16, line 26 - page 17, line 3; page 17, lines 8-13; page 21, line 11 - page 26, line 8</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1-7,12-20</td> </tr> <tr> <td colspan="3" style="text-align: center; padding: 5px;">--</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">A</td> <td style="padding: 5px;">EP, A, 0229707 (CANON K.K.) 22 July 1987, see abstract; page 7, lines 12-15; page 7, lines 29-41; figure 1</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1,3,4,7, 12,14,15</td> </tr> <tr> <td colspan="3" style="text-align: center; padding: 20px;">-----</td> </tr> </table>			Category *	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>	X	EP, A, 0140625 (THE MARCONI CO. LTD) 8 May 1985, see abstract; page 4, lines 5,6; page 5, lines 3-12; page 5, lines 19-23; page 6, lines 13-20; figure 1	1,3,4,6, 12,14,15,19	--			A	WO, A, 85/03460 (SCHMITT JEROME) 15 August 1985, see abstract; page 16, line 26 - page 17, line 3; page 17, lines 8-13; page 21, line 11 - page 26, line 8	1-7,12-20	--			A	EP, A, 0229707 (CANON K.K.) 22 July 1987, see abstract; page 7, lines 12-15; page 7, lines 29-41; figure 1	1,3,4,7, 12,14,15	-----		
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<b>IV. CERTIFICATION</b> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; border-bottom: 1px solid black; padding: 5px;">           Date of the Actual Completion of the International Search            16th November 1988         </td> <td style="width: 50%; border-bottom: 1px solid black; padding: 5px;">           Date of Mailing of this International Search Report            08 DEC 1988         </td> </tr> <tr> <td style="border-bottom: 1px solid black; padding: 5px;">           International Searching Authority            EUROPEAN PATENT OFFICE         </td> <td style="border-bottom: 1px solid black; padding: 5px;">           Signature of Authorized Officer             P.C.G. VAN DER PUTTEN         </td> </tr> </table>			Date of the Actual Completion of the International Search 16th November 1988	Date of Mailing of this International Search Report 08 DEC 1988	International Searching Authority EUROPEAN PATENT OFFICE	Signature of Authorized Officer P.C.G. VAN DER PUTTEN																	
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		EP-A- 0173715	12-03-86
		JP-T- 61501214	19-06-86
EP-A- 0229707	22-07-87	AU-A- 6751387	16-07-87
		JP-A- 62163311	20-07-87

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